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Post-traumatic knee MRI findings and associations with patient, trauma, and clinical characteristics:

a subgroup analysis in primary care in the Netherlands

Abstract

Background
The added value of magnetic resonance imaging (MRI) in primary care is still being debated. A high diagnostic yield can be expected in young and active patients with post-traumatic knee complaints.

Aim
To determine the frequency of MRI abnormalities in young and active patients (aged 18–45 years) and the associations with patient, trauma, and clinical characteristics.

Design and setting
A subgroup analysis of 174 patients, aged 18–45 years with knee trauma of <6 months, allocated to MRI in a randomised controlled trial on the yield of MRI in primary care. Patients were recruited by 150 GPs in the Netherlands from October 2012 to November 2015.

Method
Associations were expressed using mean differences, odds ratio (OR) and predictive values.

Results
Sixty-seven out of 174 patients (39%) had a positive MRI finding, predominantly anterior cruciate ligament (ACL) ruptures (22%) and/or traumatic meniscal tears (15%). Patients with a pre-existing musculoskeletal comorbidity had a two-fold lower prevalence of positive MRI findings (21%), OR 3.0 (95% confidence interval [CI] = 1.3 to 7.0). A 'sports related trauma' showed the highest OR of 4.6 (95% CI = 2.2 to 9.3) for a positive MRI finding. Clinical scores were statistically, significantly worse in patients with positive MRI findings, with mean differences ranging from 10 to 20%. Furthermore, increasing duration of complaints was correlated with decreasing prevalence rates of positive MRI findings. Overall, a popping sound and direct swelling showed the highest positive predictive value of 65% for the presence of positive MRI findings.

Conclusion
The results from this study enable a preselection of patients to increase the diagnostic yield of MRI in primary care.

Keywords
anterior cruciate ligament injuries; early diagnosis; knee injuries; magnetic resonance imaging; tibial meniscus injuries.

INTRODUCTION

GPs are often consulted for post-traumatic knee complaints.[1] Of all sport injuries, the knee is the most commonly affected joint.[2] A trauma of the knee is known to have the highest burden of all sport injuries causing a substantially lowered quality of life in predominantly young and physically active patients.[2,3] These patients suffer from knee pain and impaired knee function resulting in less mobility, work absenteeism, and decreased sports participation.[2,3] Post-traumatic knee injuries can be diagnosed with high diagnostic accuracy using magnetic resonance imaging (MRI).[4] As an established diagnostic tool in secondary care, it is mainly requested by orthopaedic surgeons to select treatment strategy, including whether surgery is needed.[5,6] During the past decades MRI has been increasingly used in primary care, with the MRI of the spine requested most, followed by the knee and the brain respectively.[5,7,8]

Negative MRI findings could reassure patients and treatment in primary care can be continued. In case of positive findings, an early MRI scan could contribute to an earlier diagnosis and dedicated treatment. Patients could return to sports or work earlier with possible improved healthcare outcomes. A high diagnostic yield can be expected especially in young patients with post-traumatic knee complaints.[5,9–11] Earlier studies in primary care have evaluated prevalence rates of MRI abnormalities in patients with knee complaints, however, these studies included older patients and patients with chronic knee complaints.[6,11–13] None of these studies assessed the associations of clinical outcomes with the overall MRI result, including combinations of important MRI findings.

The goal of this study was, therefore, to determine the frequency of MRI findings in younger patients (18–45 years) with post-traumatic knee complaints seen in primary care and to determine the associations with patient and trauma characteristics; duration of complaints; and clinical scores.

METHOD

Study design

For the current study, data were used from the TraumAtic Complaints of the Knee — Leiden University Medical Center (LUMC) and Erasmus MC (TACKLE) Trial, a multicentre randomised controlled trial (RCT) to determine the (cost-) efficacy of MRIs requested by the GP in patients with a recent knee trauma. The full research

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How this fits in

At a time of on ongoing discussion about the added value of magnetic resonance imaging (MRI) in primary care, a subgroup analysis was conducted with all patients allocated to MRI in a randomised controlled trial. A potential subgroup of patients that could benefit from MRI was studied. It contained relatively young patients (18–45 years) with post-traumatic knee complaints. The MRI findings were expounded and several patient, trauma, and clinical characteristics associated with higher prevalence rates of positive MRI findings were identified. The study findings help GPs to preselect patients with post-traumatic knee complaints in whom an increased diagnostic yield of MRI can be expected.

protocol was published earlier.[14] Patients aged 18–45 years with knee complaints after a recent knee trauma in the preceding 6 months were eligible. Exclusion criteria were indications for direct referral (fracture or a locked knee), referrals to secondary care and/or MRI already performed, previous surgery of the affected knee, knee osteoarthritis diagnosed by a physician and contraindications for MRI. Patients were enrolled from October 2012 to November 2015 by 150 GPs in the western part of the Netherlands. Eligible patients were selected during consultation by the GP or by an invitational letter from the GP within 12 weeks after the consultation. After the baseline measurement, patients were evenly allocated to usual care or to MRI. In the MRI arm patients received an MRI scan within 2 weeks after the baseline measurement, as well as usual care. Only the results of the MRI group are presented in the current study.

Table 1. Baseline patient, trauma, and clinical characteristics of patients aged 18–45 years with recent knee trauma, seen in primary care, *N* = 174

Median Age, years (IQR)	34 (26–41)
Male, *n* (%)	110 (63)
BMI, mean (SD)	25.3 (3.9)
Musculoskeletal comorbidities, *n* (%)	39 (22)
Duration of complaints, days, median, (IQR)	42 (17–83)
Sports-related trauma, *n* (%)	105 (60)
Rotational trauma, *n* (%)	70 (40)
Popping sensation during trauma, *n* (%)	64 (37)
Direct pain after trauma, *n* (%)	127 (73)
Direct swelling after trauma, *n* (%)	43 (25)
Not able to continue activity after trauma, *n* (%)	124 (71)
KOOS Pain, mean[a] (SD)	58 (20)
KOOS Symptoms, mean[b] (SD)	61 (20)
KOOS Sports, mean[c] (SD)	35 (27)

[a,b,c] Knee specific scores on respectively pain, symptoms and limitations in sports, ranging from 0 = worst score to 100 = best score. BMI = body mass index. IQR = interquartile range. KOOS = knee injury and osteoarthritis outcome score. SD = standard deviation.

MRI abnormalities

Prior to the start of this study, two orthopaedic surgeons, employed in two different participating centres of the TACKLE Trial, identified 'positive' MRI findings that may have needed further specialised assessment and treatment by an orthopaedic surgeon. These were a trabecular fracture, a complete rupture of a collateral ligament, a meniscus tear, a cruciate ligament rupture and a full thickness cartilage defect. A standardised knee MRI report was developed and the involved radiologists were trained accordingly (further details on MRI imaging in the TACKLE Trial are available from the authors).

Patient, trauma, and clinical characteristics

The following patient characteristics and data were collected:

- age;
- sex;
- body mass index (BMI);
- presence of musculoskeletal comorbidities, defined as pre-existing pain in the hip/s, ankle/s or spine;
- duration of complaints;
- trauma characteristics, including the activity during trauma (sports, work, at home, traffic); trauma mechanism (rotational, fall, bumping); a popping sensation; direct pain, direct swelling inability to continue activity and combinations.
- clinical scores — knee injury and osteoarthritis outcome score (KOOS) pain; KOOS symptoms; and KOOS sports.[15]

Statistical analysis

The data were described using absolute numbers with frequencies for binary and categorical data, means with standard deviation (SD) for normally distributed data and medians with interquartile ranges (IQR) for non-normally distributed data. Several categorical variables were dichotomised into sensible and clinically relevant variables, for example, sports-related versus non-sports-related trauma. Prior to the start of the study all meniscal tears were defined

Table 2. MRI findings in patients aged 18–45 years with recent knee trauma, seen in primary care, *N* = 174

	Prevalence of MRI finding	
Knee trauma	***n***	**%**
No abnormalities	**30**	**17**
Soft tissue	**89**	**51**
Effusion	71	41
Synovitis	36	21
Baker's cyst	23	13
Bursitis	5	3
Ganglion	5	3
Thickened plica	6	3
Bone bruises	**61**	**35**
In femorotibial joint	60	35
Medial compartment	37	21
Lateral compartment	37	21
Medial and lateral	16	9
In patella	4	2
Trabecular fracture	12	7
Cartilage defects	**39**	**22**
Femorotibial joint	28	16
Partial thickness defects	19	11
Full thickness defects	9	5
Patellofemoral joint	17	10
Partial thickness defects	16	9
Full thickness defects	1	1
Cruciate ligaments	**40**	**23**
ACL rupture	38	22
Partial	21	12
Complete	17	10
PCL complete rupture	2	1
Collateral ligaments	**27**	**16**
MCL partial distortion	16	10
MCL complete distortion	1	1
PCL partial distortion	2	1
Menisci	**67**	**39**
Medial meniscus	54	31
Mucoid degeneration	12	7
Horizontal tear	25	14
Traumatic tear	17	10
Lateral meniscus	26	15
Mucoid degeneration	4	2
Horizontal tear	9	5
Traumatic tear	13	8
Medial and/or lateral tear	54	31
Horizontal	30	17
Traumatic	26	15
Positive MRI findings[a]	**67**	**39**

[a]Positive MRI findings: trabecular fracture, traumatic meniscal tear, cruciate ligament rupture, complete rupture collateral ligament and/or a full thickness cartilage defect. ACL = anterior cruciate ligament. PCL = posterior cruciate ligament. MCL = medial collateral ligament. LCL = lateral collateral ligament.

as a positive MRI finding. However, in the analyses, presence of a horizontal meniscal tear was associated with higher age and not associated with duration of complaints, nor with any clinical outcome measure. Therefore, patients with a horizontal meniscal tear were excluded from the positive MRI findings group. Furthermore, presence of effusion and/or synovitis were combined into one variable 'effusion-synovitis' to assess the clinical correlations. The associations of MRI findings with the collected patient, trauma, and clinical characteristics were expressed using mean differences for continuous data assessed with the Student's *t*-test and odds ratios (OR) for dichotomous data using binary logistic regression analysis. Additionally, 95% confidence intervals (95% CIs) for all associations were calculated. The mean difference was preferred because this measure provides more directly relevant information than the correlation coefficient.[16] Furthermore, negative predictive values (NPVs) and positive predictive values (PPVs) were calculated for the trauma characteristics and the presence of MRI findings, using cross tabulations. To express the association of duration of complaints with the presence of MRI findings and with mean clinical scores, patients were stratified into three equal groups according to (increasing) days from trauma to MRI scan. The statistical significance of differences in prevalence and mean scores across the three strata were determined using the 1-way ANOVA test. Statistical analyses were performed with IBM SPSS (version 23.0).

RESULTS

Study population

In the TACKLE trial 174 patients received an MRI scan (Table 1). The median time from baseline measurement to MRI scan was 6 days (IQR 4–9 days), with 93% of the patients receiving the MRI scan within the scheduled 2 weeks after randomisation. Median duration of knee complaints was 42 days (IQR 17–83 days).

Prevalence of MRI findings

A positive MRI finding was present in 67 patients (39%), predominantly anterior cruciate ligament (ACL) ruptures in 38 patients (22%) and/or a traumatic meniscal tear in 26 patients (15%) (Table 2). A positive MRI finding accompanied with effusion-synovitis was found in 49 patients (73%); in 43 patients (64%) accompanied by a bone bruise; and in 59 patients (88%) accompanied by effusion-synovitis and/or a bone bruise (Figure 1). No abnormalities were found in 30 patients (17%) found, leaving 77 patients (44%) with minor MRI findings who did not require an evaluation by an orthopaedic surgeon.

Associations of MRI findings with patient and clinical characteristics

Higher age was correlated with the

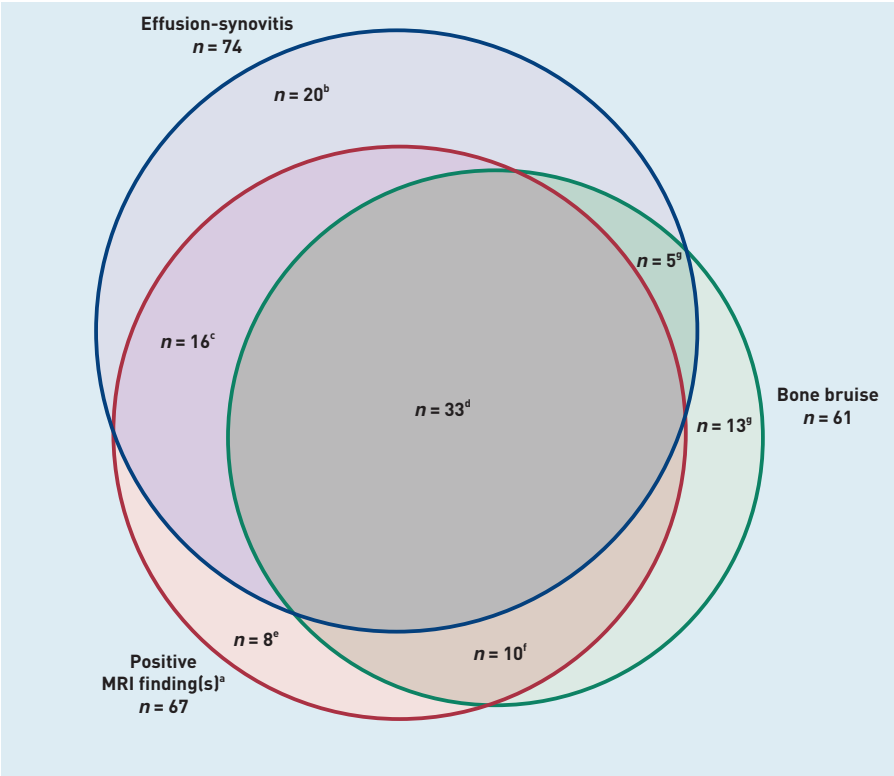

Figure 1. Venn diagram of combinations of MRI findings in patients aged 18–45 years with recent knee trauma, seen in primary care. Shown here are all patients with effusion-synovitis and/or a bone bruise and/or a positive MRI finding (N = 95 patients). Overlapping areas represent combinations of MRI findings. [a]Positive MRI finding(s): trabecular fracture, traumatic meniscal tear, cruciate ligament rupture, complete rupture collateral ligament and/or a full thickness cartilage defect. [b]Knees with effusion-synovitis, but without a bone bruise and positive MRI findings. [c]Knees with a positiive MRI finding and effusion-synovitis, but no bone bruise. [d]Knees with a positive MRI finding and effusion-synovitis and a bone bruise. [e]Knees with a positive MRI findings, but no effusion-synovitis or a bone bruise. [f]Knees with a positive MRI finding and a bone bruise, but no effusion-synovitis. [g]Knee with a bone bruise, but no positive MRI finding or effusion-synovitis. [h]Knees with effusion-synovitis and a bone-bruise, but no positive MRI finding.

presence of a horizontal meniscal tear, but with no other MRI abnormality. Patients with a horizontal meniscal tear had a mean age of 38 (SD 7) years, compared to a mean age of 32 (SD 8) years in patients without a horizontal meniscal tear; mean difference 6 (95% CI = 3 to 9) years. Furthermore, patients with pre-existing musculoskeletal comorbidities had a statistically significant lower prevalence of positive MRI findings: 8 out of 39 patients (21%) compared to 59 out of 135 patients (44%) without a musculoskeletal

Table 3. Prevalence of MRI findings and mean clinical scores according to duration of complaints from trauma to MRI scan, stratified into three equal groups, *N* = 174

		Stratum 1 (*n* = 58)		Stratum 2 (*n* = 58)		Stratum 3 (*n* = 58)		
		Duration of knee complaints (days)						
	Total	0–34		35–76		77–178		
MRI finding	*N*	*n*	%	*n*	%	*n*	%	*P*-value
Effusion-synovitis	74	39	67	21	36	14	24	<0.001
Bone bruise	61	30	52	22	38	9	16	<0.001
Fracture	12	9	16	3	5	0	0	0.004
MCL distortion	27	15	26	9	16	3	5	0.012
Horizontal meniscal tear	30	12	21	10	17	8	14	0.690
Traumatic meniscal tear	26	9	16	13	22	4	7	0.081
ACL rupture	38	18	31	14	24	6	10	0.034
Full thickness cartilage defect	9	6	10	3	5	0	0	0.048
Positive MRI findings[a]	67	34	59	25	43	8	14	<0.001
Clinical outcome measures	***N***	**mean (SD)**		**mean (SD)**		**mean (SD)**		***P*-value**
KOOS pain[b]	174	47 (18)		61 (19)		66 (19)		<0.001
KOOS symptoms[c]	174	50 (17)		62 (19)		72 (18)		<0.001
KOOS sports[d]	174	18 (20)		39 (27)		48 (24)		<0.001

[a]Positive MRI findings: trabecular fracture, traumatic meniscal tear, cruciate ligament rupture, complete rupture collateral ligament and/or a full thickness cartilage defect. [b,c,d]Knee specific scores on respectively pain, symptoms and limitations in sports, ranging 0 = worst score to 100 = best score. ACL = anterior cruciate ligament. KOOS = knee injury and osteoarthritis outcome score. MCL = medial collateral ligament.

Table 4. Trauma characteristics and associations with the predictive values for MRI abnormalities in patients aged 18–45 years and recent knee trauma seen in primary care, *N* = 174

			ACL rupture			Traumatic meniscal tear			Positive MRI finding(s)[a]		
			n = 38 (22%)			*n* = 26 (15%)			*n* = 67 (39%)		
Trauma characteristics	**Yes/No**	***n***	**OR (95% CI)**	**NPV**	**PPV**	**OR (95% CI)**	**NPV**	**PPV**	**OR (95% CI)**	**NPV**	**PPV**
Sports-related trauma	yes	105	3.7 (1.5 to 9.0)	90	30	3.2 (1.1 to 8.9)	93	20	4.6 (2.2 to 9.3)	81	51
	no	69									
Rotational trauma	yes	70	1.1 (0.5 to 2.3)	79	23	1.9 (0.8 to 4.4)	88	20	2.0 (1.1 to 3.8)	68	49
	no	104									
Popping sound	yes	64	3.1 (1.5 to 6.5)	85	34	3.3 (1.4 to 7.9)	91	25	2.1 (1.1 to 4.0)	68	50
	no	113									
Direct pain	yes	127	3.9 (1.3 to 11.8)	91	26	2.3 (0.7 to 6.9)	91	17	3.0 (1.4 to 6.6)	79	45
	no	47									
Direct swelling	yes	43	1.6 (0.7 to 3.5)	80	28	1.1 (0.4 to 2.9)	85	16	2.0 (1.0 to 4.0)	66	51
	no	131									
Inability to continue activity	yes	124	2.6 (1.0 to 6.6)	88	26	1.4 (0.5 to 3.8)	88	16	2.5 (1.2 to 5.3)	76	44
	no	50									
Combinations											
Popping sound and direct swelling	yes	17	2.8 (1.0 to 8.1)	80	41	3.7 (1.2 to 11.2)	87	35	3.3 (1.2 to 9.4)	64	65
	no	157									
Rotational trauma and direct swelling	yes	21	1.5 (0.5 to 4.2)	79	29	0.6 (0.4 to 4.6)	86	19	3.0 (1.2 to 7.6)	65	62
	no	153									

[a]*Positive MRI findings: trabecular fracture, traumatic meniscal tear, cruciate ligament rupture, complete rupture collateral ligament and/or a full thickness cartilage defect.*

ACL = anterior cruciate ligament. OR = odds ratio. NPV = negative predictive value. PPV = positive predictive value, both expressed in percentages.

comorbidity; OR 3.0 (95% CI = 1.3 to 7.0). No statistically significant associations were found between BMI, or sex, and the presence of MRI findings.

As the duration of complaints increased, fewer MRI abnormalities were observed and fewer knee specific symptoms were reported (Table 3). Only patients with a horizontal meniscal tear were evenly distributed across the three strata.

The group with positive MRI findings had statistically significant worse scores on all three tested KOOS subscales, with the highest mean difference of 22 (95% CI = 15 to 30) in the KOOS sports score. Most single positive MRI findings showed a statistically significant association with clinical scores, with the exception of the horizontal meniscal tear. Effusion/synovitis and the presence of a bone bruise were associated with significantly worse scores on the three KOOS subscales, with mean differences ranging 10–19 (95% CI = 4 to 27).

Associations of MRI findings with trauma characteristics

All trauma characteristics were statistically significantly associated with the presence of one or more positive MRI finding, of which sports-related trauma showed the strongest association (Table 4). Of the six trauma characteristics, four were associated with a higher prevalence of ACL rupture, of which 'direct pain after trauma' showed the strongest association with an OR of 3.9 (95% CI = 1.3 to 11.8). Overall high NPVs were observed: highest for sports-related trauma and direct pain after trauma, with NPVs ranging from 90% to 93%. Furthermore, highest PPVs for a positive MRI finding were seen for the combinations of a popping sound during trauma and a direct swelling, and for a rotational trauma with a direct swelling, with PPVs ranging from 62% to 65% (Table 4). The classical combination of a popping sound and a direct swelling showed a 41% PPV for an ACL rupture.

DISCUSSION

Summary

In this study the MRI findings in young adults with a recent knee trauma seeking medical attention in primary care were investigated. Almost 40% of the patients had one or more positive MRI findings potentially requiring further evaluation by an orthopaedic surgeon. These findings were usually accompanied by effusion-synovitis and/or a bone bruise. Patients without a pre-existing musculoskeletal comorbidity showed a twofold higher prevalence of these positive MRI findings. Increasing duration of complaints was associated with decreasing prevalence rates of positive MRI findings. Six

trauma characteristics showed a statistically significant association with positive MRI findings of which sports-related trauma showed the highest OR. A popping sound with a direct swelling showed the highest PPV for a positive MRI finding. Patients with a positive MRI finding showed statistically significantly more impaired knee function and more knee pain.

Strengths and limitations

A strength of this study is the selection of patients in which the highest yield of MRI imaging is expected, including young patients aged 18 to 45 years with post-traumatic knee complaints, thereby excluding older patients with possible degenerative findings that are often confusing to clinicians and lack therapeutic options. Furthermore, the overall MRI result was focused on and correlated with clinical scores, not exclusively concentrating on single ligamentous or meniscal injuries.

There were some limitations. No information was gathered on the findings of physical examinations performed by the GP. This decision was based not only on logistical reasons with the primary goal of the TACKLE trial being the yield of MRI imaging in primary care, but also on evidence from the literature showing the minor to absent added value of physical examination of the knee by GPs for the diagnosis of ACL ruptures and meniscal tears.[13,17,18] Furthermore, the tested associations in this study were based on MRI findings and not confirmed by arthroscopy. However, MRI imaging is known to have high diagnostic accuracy for post-traumatic knee injuries.[19] A few false positive or false negative findings could have been made, but were unlikely to influence the main results.

Comparison with existing literature

Prevalence rates of MRI findings in this study are comparable with earlier studies in patients with post-traumatic knee complaints seen in primary care. In the present sample, 15% of the patients had a traumatic meniscal tear, this is comparable with the prevalence rate of 17% in a similar group of primary care patients.[12] An overall meniscal tear prevalence rate of 31% was observed in this study, in contrast to 47% in the aforementioned study. This could be due to the relatively older patients included in their study with a mean age of 41 years.[12] For ACL ruptures, those authors found a prevalence rate of 17%. In another study in primary care (with a trauma rate of 66%) 18% of the patients had an ACL rupture; this was 22% in the present cohort.[13]

Another marked finding was the relative high frequency (17%) of horizontal meniscal tears in the present targeted population, which were not associated with higher scores on pain or function loss. A horizontal tear is generally believed to be of degenerative origin. First a linear signal change inside the meniscus develops, reflecting slowly developing meniscal degradation; most of these signal changes later progress to horizontal meniscal tears.[20] Earlier studies already suggested these tears were an incidental finding, but these studies were performed in older patients.[12,20,21] Results from this study provide additional evidence that an isolated horizontal meniscal tear should be considered an age-related phenomenon, not requiring referral to an orthopaedic surgeon, even in relatively young adults with post-traumatic knee complaints.

An important finding in this study was the decreasing prevalence rates of most MRI findings with increasing duration of complaints. This was also true for the prevalence rates of positive MRI findings. The clinical outcome scores were expected to improve over time but this clear association was not foreseen. An earlier study assessed duration of complaints and the association with the prevalence of positive MRI findings, but found no statistically significant difference.[22] However, in that study, the mean duration of symptoms was over 6 months, a time period in which the effect is probably diminished. The finding in this study can be explained by the natural recovery of patients in which bone bruises resolve, effusion diminishes, and injuries to the meniscus and collateral ligaments heal. There is also evidence that partial and even complete ACL ruptures can regain continuity over time, although, the time span in this study might be too short for this event to occur.[23] Another possible explanation is that earlier consultation was achieved by patients with more severe complaints, resulting in a shorter period from trauma to MRI imaging.

A new finding in this study is the association of pre-existing musculoskeletal comorbidities with a lower prevalence of positive MRI findings. A musculoskeletal comorbidity is known to be associated with a higher score on knee specific pain subscales,[24] but to the authors' knowledge, no earlier studies reported on the lower prevalence of MRI findings in these relatively younger patients with recent knee trauma. Future studies should confirm the finding in this study. The strongest association of a trauma characteristic with positive MRI

findings was 'sports-related trauma', with a 30% higher prevalence rate of positive MRI findings compared to a non-sports-related knee trauma. This association was not found in previous studies.[17,18,25] However, a recent study confirmed a statistically significant association of a sport-related trauma with a higher prevalence of medial meniscal tears, compared to patients with non-sports-related knee trauma.[26]

Implications for practice

This article presents an overview of MRI findings observed in a population of young patients, aged 18–45 years, with traumatic knee complaints. Several patient, trauma, and clinical characteristics associated with positive MRI findings were identified. Duration of complaints should be considered by the GP when referring a patient for an MRI scan to appraise the possible yield of MRI imaging. Sports-related trauma is a strong predictor for positive MRI findings, while the presence of a musculoskeletal comorbidity results in less positive MRI findings. Furthermore, horizontal meniscal tears are, even in relatively young adults with a recent knee trauma, an incidental finding without clinical relevance. The predictive values of the trauma characteristics could enable a preselection of patients with a greater likelihood of having an abnormal MRI scan, thereby increasing the yield of MRI in primary care.

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Ethical approval

All patients approved and signed the informed consent form. The study has been approved by the Medical Ethics Committee of the Erasmus Medical Centre (Dutch Trial Registration: NTR3689).

Provenance

Freely submitted; externally peer reviewed.

Competing interests

The authors have declared no competing interests.

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REFERENCES

1. van der Linden MW, Westert GP, de Bakker DH, Schellevis FG. Second Dutch study for diseases and management in general practice: complaints and disorders in the population and in general practice? [In Dutch]. Utrecht, Bilthoven: NIVEL/RIVM, 2004. https://www.nivel.nl/sites/default/files/bestanden/ns2_r1_h00.pdf (accessed 31 Oct 2017).
2. Veiligheid NL. [SafetyNL.] Sport injuries, injury rates 2013. [In Dutch]. https://www.veiligheid.nl/sportblessures/kennis/cijfers-over-sportblessures. Veiligheid NL, 2015. (accessed 31 Oct 2017).
3. Wagemakers HP, Luijsterburg PA, Heintjes EM, *et al.* Outcome of knee injuries in general practice: 1-year follow-up. *Br J Gen Pract* 2010; DOI: https://doi.org/10.3399/bjgp10X483157.
4. Oei EH, Nikken JJ, Verstijnen AC, *et al.* MR imaging of the menisci and cruciate ligaments: a systematic review. *Radiology* 2003; **226(3):** 837–848.
5. Roberts TT, Singer N, Hushmendy S, *et al.* MRI for the evaluation of knee pain: comparison of ordering practices of primary care physicians and orthopaedic surgeons. *J Bone Joint Surg Am* 2015; **97(9):** 709–714.
6. Sherman PM, Penrod BJ, Lane MJ, Ward JA. Comparison of knee magnetic resonance imaging findings in patients referred by orthopaedic surgeons versus nonorthopaedic practitioners. *Arthroscopy* 2002; **18(2):** 201–205.
7. Gough-Palmer AL, Burnett C, Gedroyc WM. Open access to MRI for general practitioners: 12 years' experience at one institution — a retrospective analysis. *Br J Radiol* 2009; **82(980):** 687–690.
8. Lehnert BE, Bree RL. Analysis of appropriateness of outpatient CT and MRI referred from primary care clinics at an academic medical center: how critical is the need for improved decision support? *J Am Coll Radiol* 2010; **7(3):** 192–197.
9. Pompan DC. Appropriate use of MRI for evaluating common musculoskeletal conditions. *Am Fam Physician* 2011; **83(8):** 883–884.
10. Subhas N, Patel SH, Obuchowski NA, Jones MH. Value of knee MRI in the diagnosis and management of knee disorders.*Orthopedics*; **37(2):** e109–e116.
11. Berg HF, Vermeulen M, Algra PR, Boonman-de Winter LJ. Direct access to magnetic resonance imaging improved orthopaedic knee referrals in the Netherlands. *Fam Pract* 2016; **33(5):** 482–487.
12. Boks SS, Vroegindeweij D, Koes BW, Hunink MM *et al.* Magnetic resonance imaging abnormalities in symptomatic and contralateral knees: prevalence aand associations with traumatic history in general practice. *Am J Sports Med.* 2006; **34(12):** 1984–1991.
13. Snoeker BA, Lindeboom R, Zwinderman AH,*et al.* Detecting meniscal tears in primary care: reproducibility and accuracy of 2 weight-bearing and 1 non-weight-bearing test. *J Orthop Sports Phys Ther* 2015; **45(9):** 693–702.
14. Swart NM, van Oudenaarde K, Algra PR, *et al.* Efficacy of MRI in primary care for patients with knee complaints due to trauma: protocol of a randomised controlled non-inferiority trial (TACKLE trial). *BMC Musculoskelet Disord* 2014; **15(1):** 63.
15. de Groot IB, Favejee MM, Reijman M, *et al.* The Dutch version of the knee injury and osteoarthritis outcome score: a validation study. *Health Qual Life Outcomes* 2008; **6(16):** 16.
16. Laupacis A, Sackett DL, Roberts RS. An assessment of clinically useful measures of the consequences of treatment. *N Engl J Med* 1988; **318(26):** 1728–1733.
17. Wagemakers HP, Heintjes EM, Boks SS, *et al.* Diagnostic value of history-taking and physical examination for assessing meniscal tears of the knee in general practice. *Clin J Sport Med* 2008; **18(1):** 24–30.
18. Wagemakers HP, Luijsterburg PA, Boks SS, *et al.* Diagnostic accuracy of history taking and physical examination for assessing anterior cruciate ligament lesions of the knee in primary care. *Arch Phys Med Rehabil* 2010; **91(9):** 1452–1459.
19. Oei EHG, Ginai AZ, Hunink MGM. MRI for traumatic knee injury: a review. *Semin Ultrasound CT MRI* 2007; **28(2):** 141–157.
20. Kumm J, Roemer FW, Guermazi A, *et al.* Natural history of intrameniscal signal intensity on knee MR images: six years of data from the osteoarthritis initiative. *Radiology* 2016; **278(1):** 164–171.
21. Englund M, Guermazi A, Gale D, *et al.* Incidental meniscal findings on knee MRI in middle-aged and elderly persons. *N Engl J Med* 2008; **359(11):** 1108–1115.
22. Wylie JD, Crim JR, Working ZM, *et al.* Physician provider type influences utilization and diagnostic utility of magnetic resonance imaging of the knee. *J Bone Joint Surg* 2015; **97(1):** 56–62.
23. Boks SS, Vroegindeweij D, Koes BW, *et al.* Follow-up of posttraumatic ligamentous and meniscal knee imaging: systematic review. *Radiology* 2006; **238(3):** 863–871.
24. Suri P, Morgenroth DC, Kwoh CK, *et al.* Low back pain and other musculoskeletal pain comorbidities in individuals with symptomatic osteoarthritis of the knee: data from the osteoarthritis initiative. *Arthritis Care Res (Hoboken)* 2010; **62(12):** 1715–1723.
25. Geraets SE, Meuffels DE, van Meer BL, *et al.* Diagnostic value of medical history and physical examination of anterior cruciate ligament injury: comparison between primary care physician and orthopaedic surgeon. *Knee Surg Sports Traumatol Arthrosc* 2015; **23(4):** 968–974.
26. Pezeshki S, Vogl TJ, Pezeshki MZ, *et al.* Association of the type of trauma, occurrence of bone bruise, fracture and joint effusion with the injury to the menisci and ligaments in MRI of knee trauma. *Muscles Ligaments Tendons J* 2016; **6(1):** 161–166.